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ANALYSIS OF METHODS AND PROSPECTS FOR APPLICATION OF OPTICAL METHODS FOR CONTROL OF WORKING SURFACES OF CYLINDER LINERS OF INTERNAL COMBUSTION ENGINES

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Abstract: Purpose of the study: analysis of methods for assessing wear and monitoring of new and worn cylinder liners of diesel and gas diesel engines D-243. During the research, the laws of the theory of lubrication, wear friction, as well as methods based on existing regulatory documents were used. As can be seen from the analysis results, the main share of the yield falls on metal particles.It has been established that the content of wear products in samples of engine oil running on gaseous fuel is less than in samples of engine oil running on diesel fuel. After a given operating time, the condition of the cylinder liners of a gas engine based on diesel engines was monitored. Using a bore gauge micrometer, measurements of the internal diameter were taken in 8-10 planes. The measurement results show deviations from the specified size.

Keywords: liner, diesel, pollution, concentration, oil, micrometer, motor.

Introduction. It is indicated that with the invention and development of holography and holographic interferometry, a real opportunity has arisen to carry out non-destructive testing of objects, on their basis, to monitor the working surfaces of the cylinder liners of the above engines, including where previously only linear and weight methods were used for these purposes.

Increasing the performance indicators of diesel engines and gas engines based on diesel engines while simultaneously reducing emissions of harmful substances into the atmosphere is one of the main problems of modern engine building. During engine operation, as a result of natural wear of the liner, the uneven operation of the cylinders increases, performance characteristics decrease, and technical and operational indicators deteriorate. When operating diesel engines and gas engines based on diesel engines, cylinder liners are exposed to high temperatures and pressure, as a result of which microroughness appears on the working surface under the influence of tribomechanical and tribological influences. To determine the amount of wear, integral and differential measurement methods are used. The differential measurement method allows you to determine wear values over the entire surface. To determine the amount of wear on the working surface of engine cylinder liners, various measurement methods are widely used.

The most widely used and widespread method for determining the wear of parts is the micrometric measurement method. This method is most often used in determining the absolute values of liner wear. It is based on measuring the dimensions of the liner using mechanical contact or some other devices before and after wear tests. Micrometering of the liner must be carried out in different planes and sections, at least 10, which requires a long time. In addition, due to the difference in the temperature of the cylinder liner during measurements, as well as possible differences in the temperatures of the tool and the part being measured, and the pressure of the measuring tip on the surface during repeated measurements during micrometering, measurement errors may occur[1-4]. Micrometering of cylinder liners of diesel engines and gas engines of tractor engines is considered promising for assessing large amounts of surface wear. The possibility of using digital holographic interferometry and laser measurements is being considered[4-7].

Purpose of the study: to carry out inspection of new and worn cylinder liners of diesel engines and gas diesel engines D-243, agricultural and transport tractors in order to identify the places of greatest and least wear using digital holographic interferometry and laser measurements. The studies analyzed existing methods for determining the amount of wear on the inner surface of a cylinder liner. And the prospects for the use of optical methods, methods of digital holographic interferometry and laser measurements in monitoring the amount of wear on the working surface of the cylinder liner of diesel and gas engines.

Materials and methods. The main source of mechanical losses in an internal combustion engine is the cylinder-piston group (CPG). According to literary sources, it accounts for up to 70% of all friction losses [1].

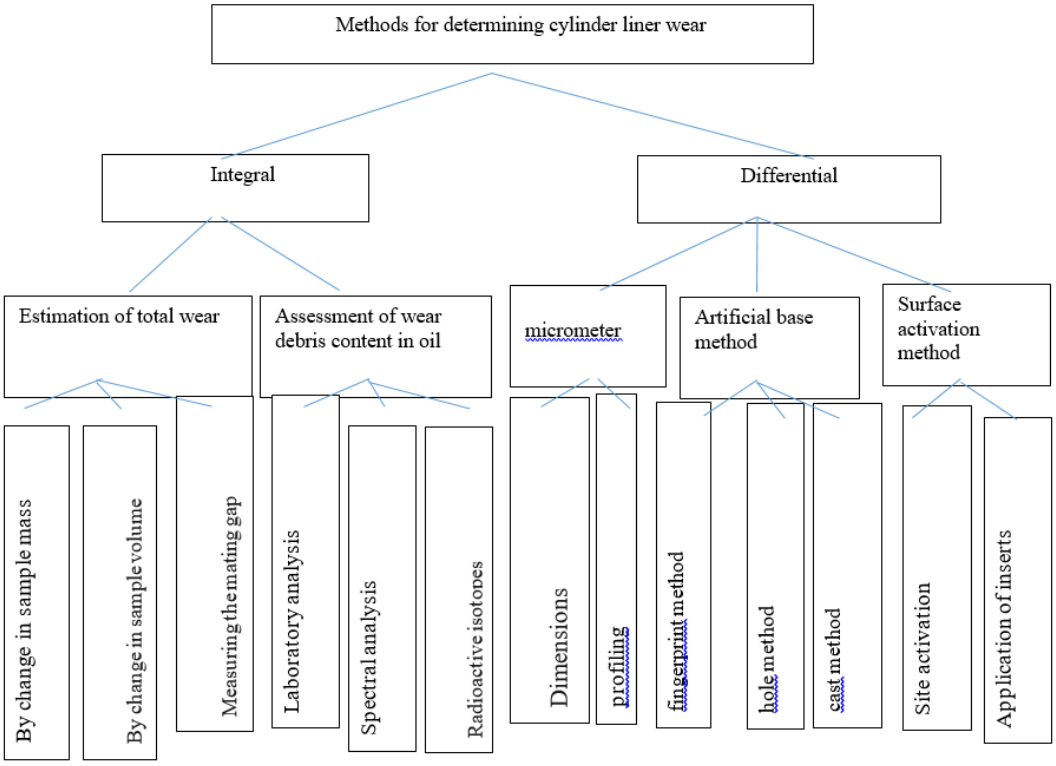

Fig.1. Methods for determining cylinder liner wear.

During engine operation, the cylinder liner operates under conditions of sharply variable pressures in the above-piston cavity. Its walls are in contact with flames and hot gases, heated to a temperature of 1500...2500°C, and the average sliding speed of the piston along the working surface varies within 11...17 m/s [8-14].

In addition, in this zone the piston shifts, accompanied by shock loads on the cylinder walls.

Under the influence of high radial pressure of the rings, the oil film on the cylinder walls ruptures, accompanied by a significant increase in friction, which leads to intense wear of the cylinder and piston rings[13-15].

There are a number of methods for measuring the amount of wear of a cylinder liner: surface activation method - the essence of this method is the influence of activation by charged particles [1].

Micrometric measurement method, weighing method; method for assessing wear by the content of wear products in oil; method of radioactive tracers and isotopes; embedded sensor method for wear assessment; artificial base method. In recent years, optical methods for assessing wear have found wide application.

Micrometer measurements refer to traditional methods of measuring linear dimensions; with micrometer measurements it is difficult to assess the nature of wear.

When measuring the wear of cylinder liners on diesel-based gas engines, the weight method has not found wide application; it is typical for parts with a lighter weight [15].

$$I = \frac{Q}{S\nu L 10^5} \quad (1)$$

where: Q – weight wear, mg;

S – friction surface area, cm^2;
v – specific gravity of the material, g/cm^3;
L – friction path, m.

In some cases, with minimal wear values, surface profiling can also be used. When profiling the surface, the initial amount of wear is measured; the essence of the method is to determine the difference in the height of the roughness from the line of the depressions to the ridge, measured in different planes of the surface of the liner.

The artificial base method is used to determine the amount of local linear wear of the surface in certain areas in which the base is applied; using this method, the shape of the deviation of the worn surface of the liners is usually determined. The depth of the applied imprint can be calculated using the formula[15].:

$$h = \frac{d}{7} \quad (2)$$

where d- is the diagonal of the print, mm.

The amount of linear wear of a flat surface is determined as the difference between the depths of the imprint before the start of wear and after the end:

$$h = h_1 - h_2 = \frac{(d_1 - d_2)}{7} \quad (3)$$

where h_1 is the depth of the indentation before wear begins, mm;
h_2 – indentation depth after wear, mm;
d_1 – diagonal of the print before wear begins, mm;
d_2 – diagonal of the print after wear, mm.

The method for determining the amount of wear based on the content of wear products in the oil is characterized by a laboratory study of used oil based on the content of wear products. A sample taken from the crankcase of a gas engine after stopping is subjected to thorough mixing and settling.

In laboratory conditions, the accumulation of wear products and organic and inorganic chemicals is determined. This method does not require disassembling the engine structure.

In studies of cylinder liner wear, it is possible to use the surface activation method, which is based on measuring the decrease in radioactivity during wear of the inner and outer surface of the tested cylinder liner in specified areas.

Applying a radioactive volume to a depth of 0.05...0.4 mm by irradiating the area with charged particles. However, this method is advisable to use after discarding the sleeve [15].

The literature contains information on the use of electrical inductive sensors, which can be used to measure wear during testing without stopping the machine. The main advantages of the inductive wear measurement method are: high measurement accuracy, which can compete with the accuracy of optical measurements; simplicity of the device, reliability and long service life; possibility of remote measurement; the ability to record changes in wear during testing in the form of a diagram; relatively low cost [15].

To determine the amount of wear of cylindrical liners during testing without stopping the machine, wire resistance sensors have been used. They serve to convert mechanical movement into a change in the electrical resistance of the sensor.

When operating diesel engines and gas diesel engines, cylinder liners are exposed to high temperature and pressure, as a result of which microroughness appears on the working surface under the influence of tribomechanical and tribological influences. Linear and weight methods are used, as well as the micrometer method.

To determine the amount of wear on the working surface of engine cylinder liners, linear and weight methods, as well as the micrometer method, are widely used [1].

It is now generally accepted that the so-called "digital" has penetrated into all areas of our lives and successfully continues to increase the "depth of penetration". It is no longer possible to imagine planning and processing the results of a complex physical, or any other scientific experiment, calculating the trajectories of spacecraft, reasonable planning and forecasting the results of economic activity without the use of digital technologies.

There are many ways to obtain holographic interferograms, allowing for studies of static, dynamic, vibration and other deformation processes, but they all combine such basic advantages as: contactless and simultaneous receipt of information about the movement of all points on the surface of an object; absence of limiting requirements for the quality of surface treatment and their shape; the presence of a measure - the length of a light wave, known with metrological accuracy - directly in the experiment; the possibility of quantitative measurements with high accuracy and high spatial resolution of surface movements of the research object.

Monitoring the condition of the inner surface of the cylinder liner of diesel and gas engines clearly demonstrates the fact that digital holographic monitoring not only ensures the identification of zones where limit states occur, but also provides a reliable quantitative assessment of the condition of the working surface of the cylinder liner [2].

Figure 2 shows the optical scheme for recording focused image holograms.

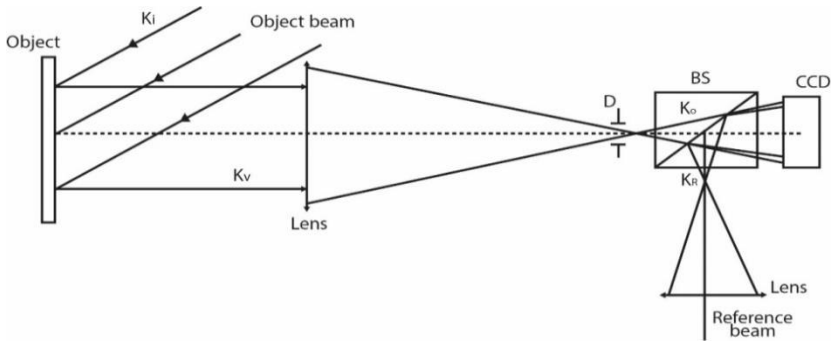

Fig.2. Optical circuit for recording a digital hologram

Results and discussion. To assess the amount of wear, oil samples were obtained from a running gas engine after the engine was stopped. The obtained samples were

analyzed in laboratory conditions according to the standard method for the content of wear products. Metal particles are generally called iron content.

During operational tests using the developed method, oil samples were obtained in the required quantities for control. The content of mechanical impurities in the operating oil was determined under laboratory conditions. As the duration of work increases, the amounts of mechanical and insoluble products increase. The main share in the composition of mechanical impurities falls on wear products.

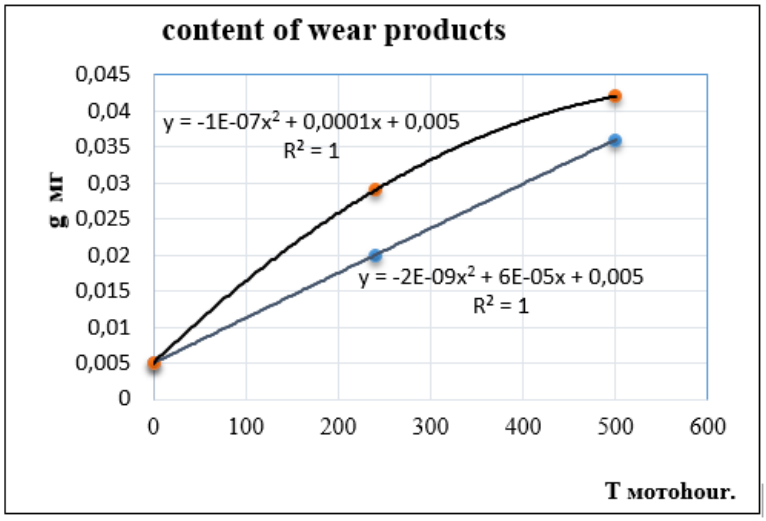

Fig.3. Dependence of the content of mechanical impurities in the oil on the duration of engine operation.

As can be seen from the analysis results, the main share of the yield falls on metal particles.

It has been established that the content of wear products in samples of engine oil running on gaseous fuel is less than in samples of engine oil running on diesel fuel.

After a given operating time, the condition of the cylinder liners of a gas engine based on diesel engines was monitored. Using a bore gauge micrometer, measurements of the internal diameter were taken in 8-10 planes. The measurement results show deviations from the specified size.

Analysis of the results of measurements of the internal diameters of cylinder liners of diesel and gas diesel engines confirms that the values of the maximum maximum deviations of dimensions vary from 0.02 to 0.61 mm, the range of spread, the ovality value is in the range of 0.02 ÷ 0.19 mm, and the taper - 0.02÷0.53 mm.

Conclusions. The results of the studies show that the amount of wear in the measured planes of cylinder liners of the D-243 engine after operation showed that the distribution of maximum deviations in dimensions, shapes of deviations - ovality and taper of liners obeys the Weibull law. By analyzing the amount of wear based on the content of wear products, it is difficult to accurately assess the amount of wear and the form of deviation from the specified one.

Micrometering of the liner must be carried out in different planes and sections, at least 10, which requires a long time. Micrometering of the liner must be carried out in different planes and sections, at least 8-10, which requires a long time.

In addition, due to the difference in the temperature of the cylinder liner during measurements, as well as possible differences in the temperatures of the tool and the part being measured, and the pressure of the measuring tip on the surface during repeated measurements during micrometering, measurement errors may occur.

Micrometering of cylinder liners of diesel engines and gas-diesel engines of a tractor engine is considered promising for assessing large amounts of surface wear. The possibility of using digital holographic interferometry and laser measurements is being considered.

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